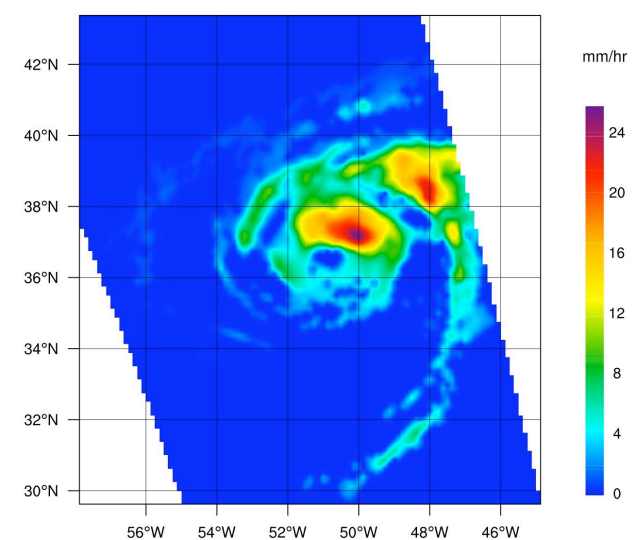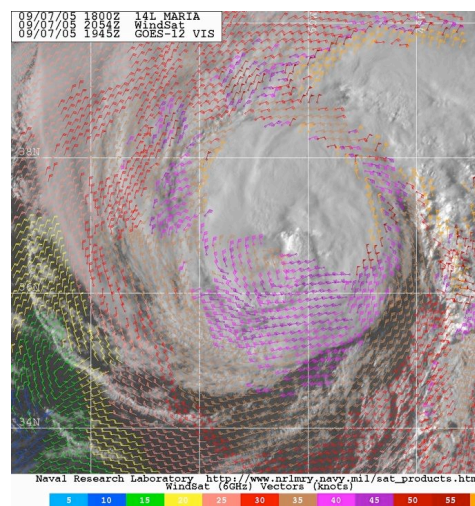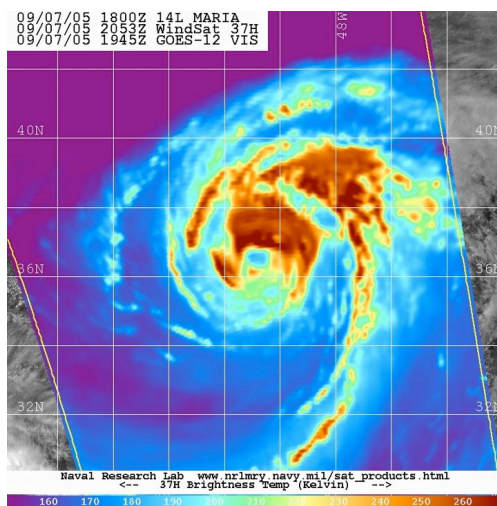# WindSat Spaceborne Polarimetric Microwave Radiometer: Mission Overview

Polar Max 06

24 October 2006

Peter Gaiser

Remote Sensing Division

Naval Research Laboratory

Washington, DC 20375-5000

WindSat/*Coriolis* – Mission Overview

- **Demonstrate Ocean Surface Wind Speed and Direction Measurement Capability From Space With Polarimetric Microwave Radiometry**
  - **Wind Vector Is a High Priority EDR for the Navy**
  - **Risk Reduction for NPOESS Microwave Imager**

- **NRL Responsible for Science, Payload Development, Mission Management, Vehicle Integration, and Cal/Val**
  - **Successful Ops *(3.5 Years and Counting!)***
  - **An Inter-Agency (IPO/Navy/USAF) Cooperation Success Story**

- **WindSat/*Coriolis* Successfully Demonstrated Capability of Polarimetric Microwave Radiometry to Measure Ocean Surface Wind Vector**

WindSat's Unique Data Set Is Available to the Science and Operational User Communities

Launched January 6, 2003

WindSat and NPOESS Risk Reduction

- **WindSat Provides Risk Reduction to NPOESS and NPOESS Users in Many Ways**
  - **Space Borne Demonstration of Capability of Polarimetric Microwave Radiometry to Measure the Ocean Surface Wind Direction**
  - **WindSat Lessons Learned**
    - **Hardware Development and Testing (Antenna Characterization, Receiver Design and Testing)**
    - **Calibration and Data Processing (Warm Load Target Design, On-orbit Anomalies, RFI Detection and Mitigation)**
  - **WindSat Data Used to Develop NPOESS Microwave Imager Data Assimilation and Other Applications (*Not Just Wind Vectors*)**
  - **Coriolis/WindSat Mission Uses NPOESS Ground Segment for Data Downlink and Distribution**

WindSat Team Adds to Pool of Microwave Remote Sensing Expertise Available to the IPO

WindSat Payload Configuration
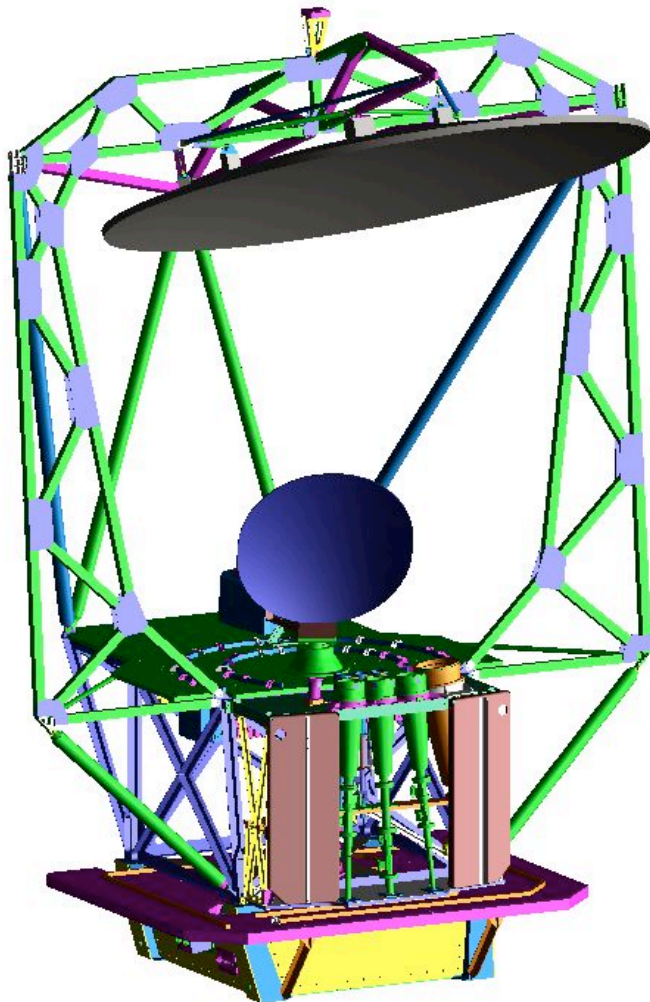
Freq, GHz	Channels	BW, MHz	EIA, deg	IFOV, km
6.8	v, h	125	53.5	40x60
10.7	v, h, ±45, lc, rc	300	49.9	25x38
18.7	v, h, ±45, lc, rc	750	55.3	16x27
23.8	v, h	500	53.0	12x20
37.0	v, h, ±45, lc, rc	2000	53.0	8x13

Height	10.5 ft
Width	8.25 ft
Mass	661 lbs.
Power	311 Watts
Spin Rate	31.6 rpm

WindSat Mission and Data

- **WindSat/Coriolis Flies in Sun Synchronous Orbit at an 840-km Altitude**
  - **1800 LTAN**
  - **1000-km Swath Width**
- **Multiple Data Products Produced**
  - **SDRs:**
    - **Calibrated, Geolocated Brightness Temperatures**
  - **EDRs:**
    - **Ocean Surface Wind Vector, SST, Total Precipitable Water, Cloud Liquid Water, Ocean Rain Rate, Sea Ice Concentration**
- **Using Multiple Products Adds Insight and Value**
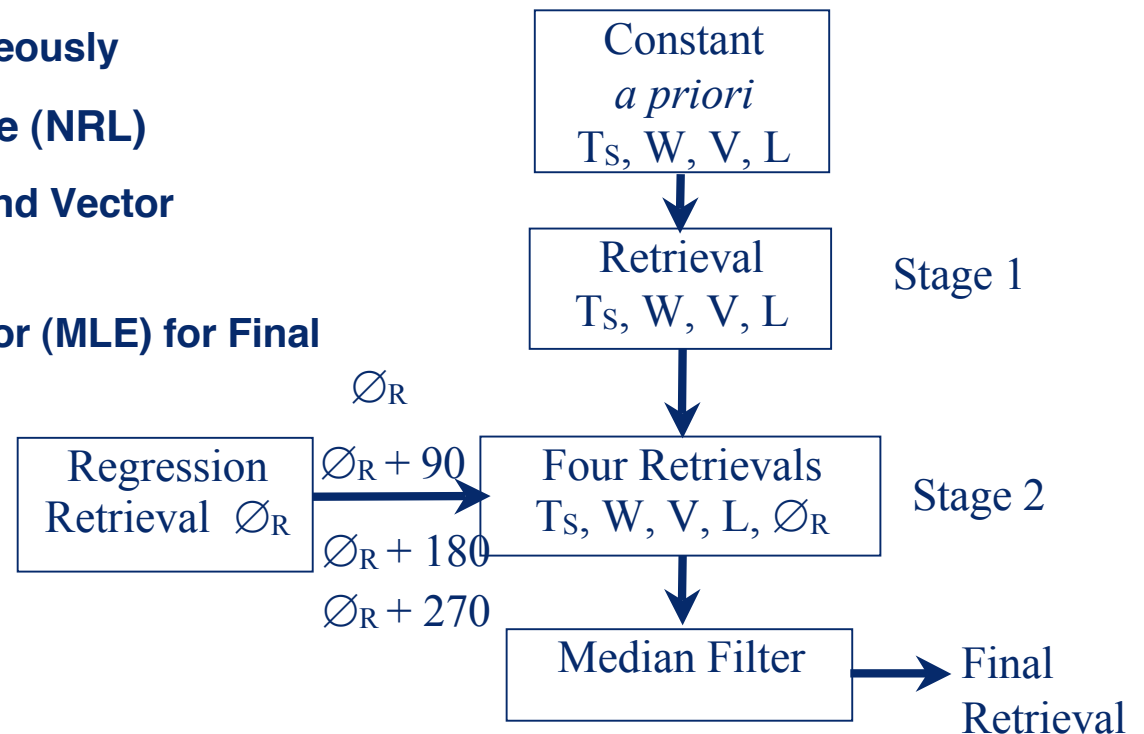
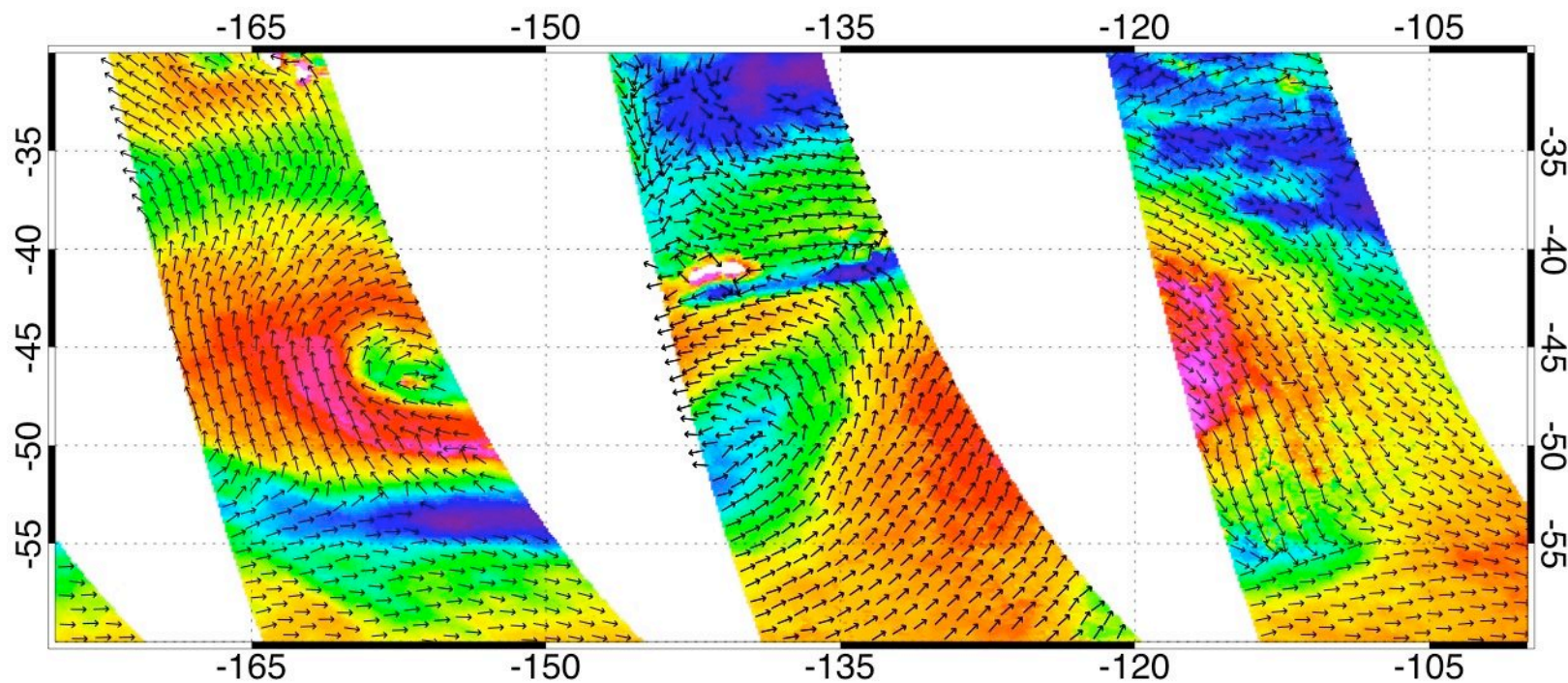**Coriolis Satellite at Launch Site**

Ocean Retrievals

- **Physically-based Algorithm Using Nonlinear Optimization (NRL)**

  - **Uses Physical Forward Model**

  - **Solves for All EDRs Simultaneously**

- **Empirical Regression Technique (NRL)**

  - **Two-stage Regression for Wind Vector Components**

  - **Maximum Likelihood Estimator (MLE) for Final Wind Direction**

- **Retrieved EDRs**

  - **Ocean Surface Wind ($W, \varnothing_R$)**

  - **Sea Surface Temperature (T_S)**

  - **Columnar Water Vapor (V)**

  - **Cloud Liquid Water (L)**

  - **Rain Rate (R)**

Constant *a priori* T_S, W, V, L

Retrieval T_S, W, V, L — Stage 1

$\varnothing_R$

Regression Retrieval $\varnothing_R$

$\varnothing_R + 90$

$\varnothing_R + 180$

$\varnothing_R + 270$

Four Retrievals $T_S, W, V, L, \varnothing_R$ — Stage 2

Median Filter → Final Retrieval

WindSat Near Real Time Retrieval

WindSat Wind Field
OE NRT 1.9.1 20060209 - Ascending

WindSat Demonstrated Wind Vector Retrieval via Polarimetric Microwave Radiometry

Median Filtered/Nudged
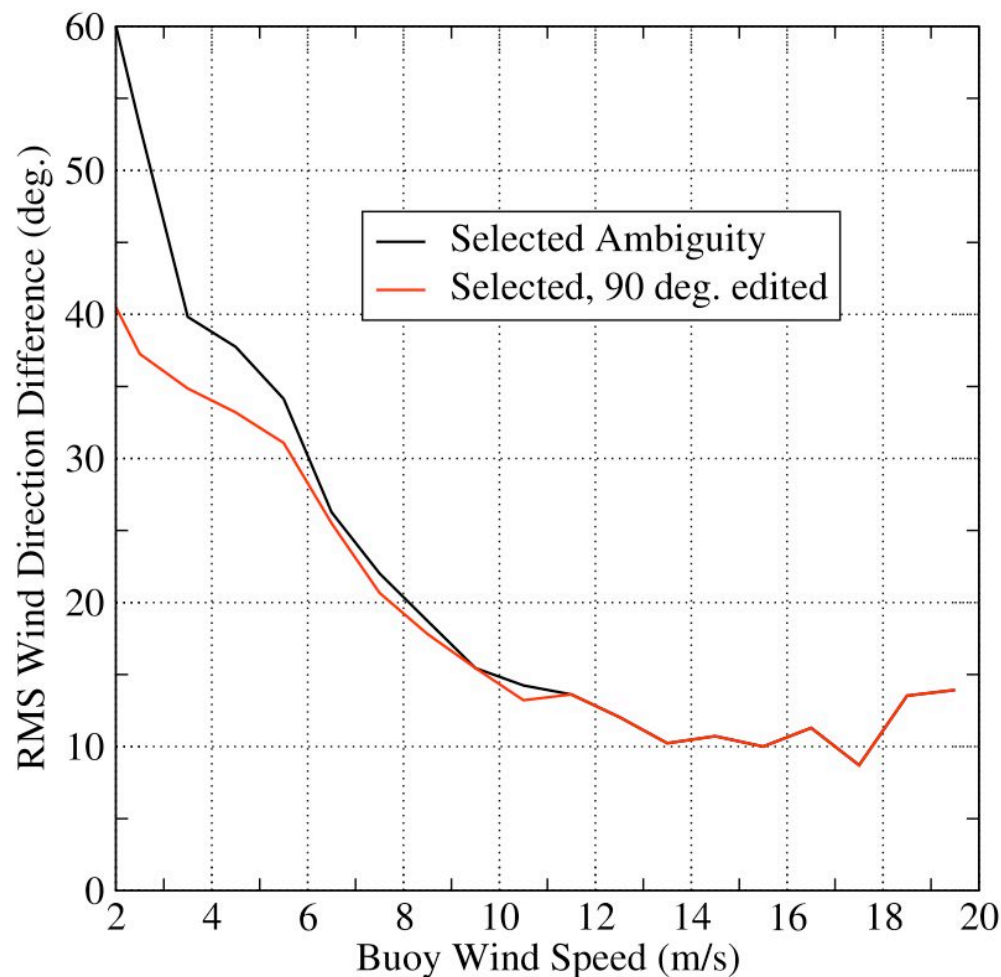
Wind Speed Bias: 0.2 m/s

Wind Speed Std. Dev.: 1.2 m/s

10406 Collocations

Percent 90° Edited *

4 - 6 m/s	6 - 8 m/s	8 - 10 m/s	> 10 m/s
1.5	0.5	0.2	0.1

* Remove Ambiguities > 90° From Truth

WindSat/*Coriolis* Is Providing Operational Data Products Today!

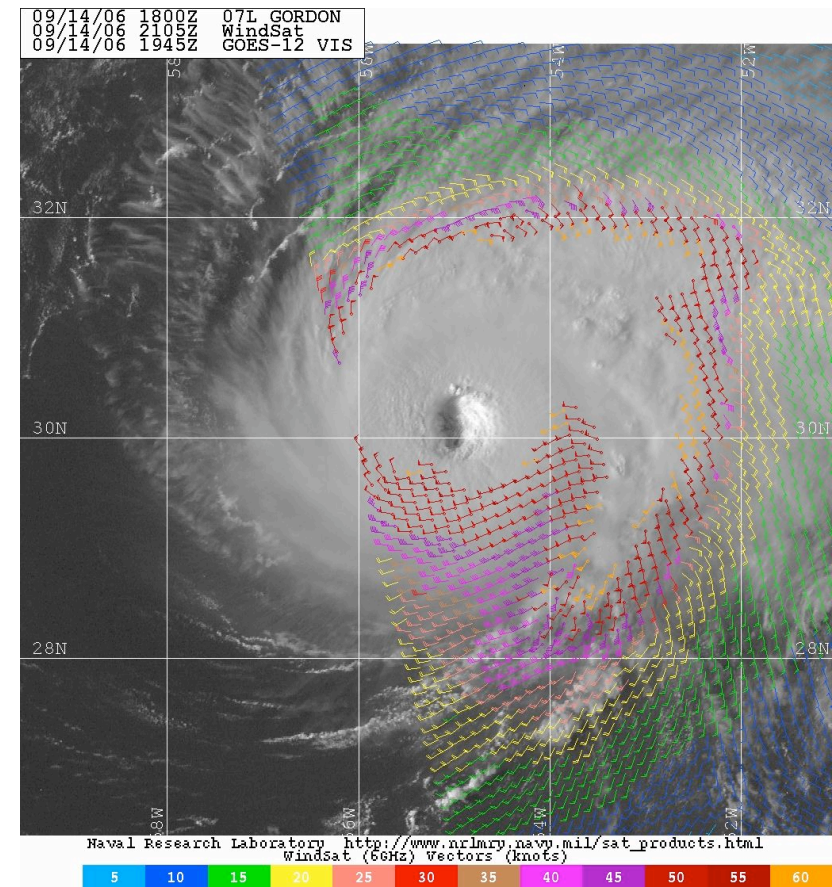## Hurricane Gordon - 14 Sep 2006

Imagery

Wind Field

09/14/06 1800Z 07L GORDON
09/14/06 2104Z WindSat 37H
09/14/06 1945Z GOES-12 VIS

09/14/06 1800Z 07L GORDON
09/14/06 2105Z WindSat
09/14/06 1945Z GOES-12 VIS

Naval Research Lab www.nrlmry.navy.mil/sat_products.html
<-- 37H Brightness Temp (Kelvin) -->

160 170 180 190 200 210 220 230 240 250 260

Naval Research Laboratory http://www.nrlmry.navy.mil/sat_products.html
WindSat (6GHz) Vectors (knots)

5 10 15 20 25 30 35 40 45 50 55 60

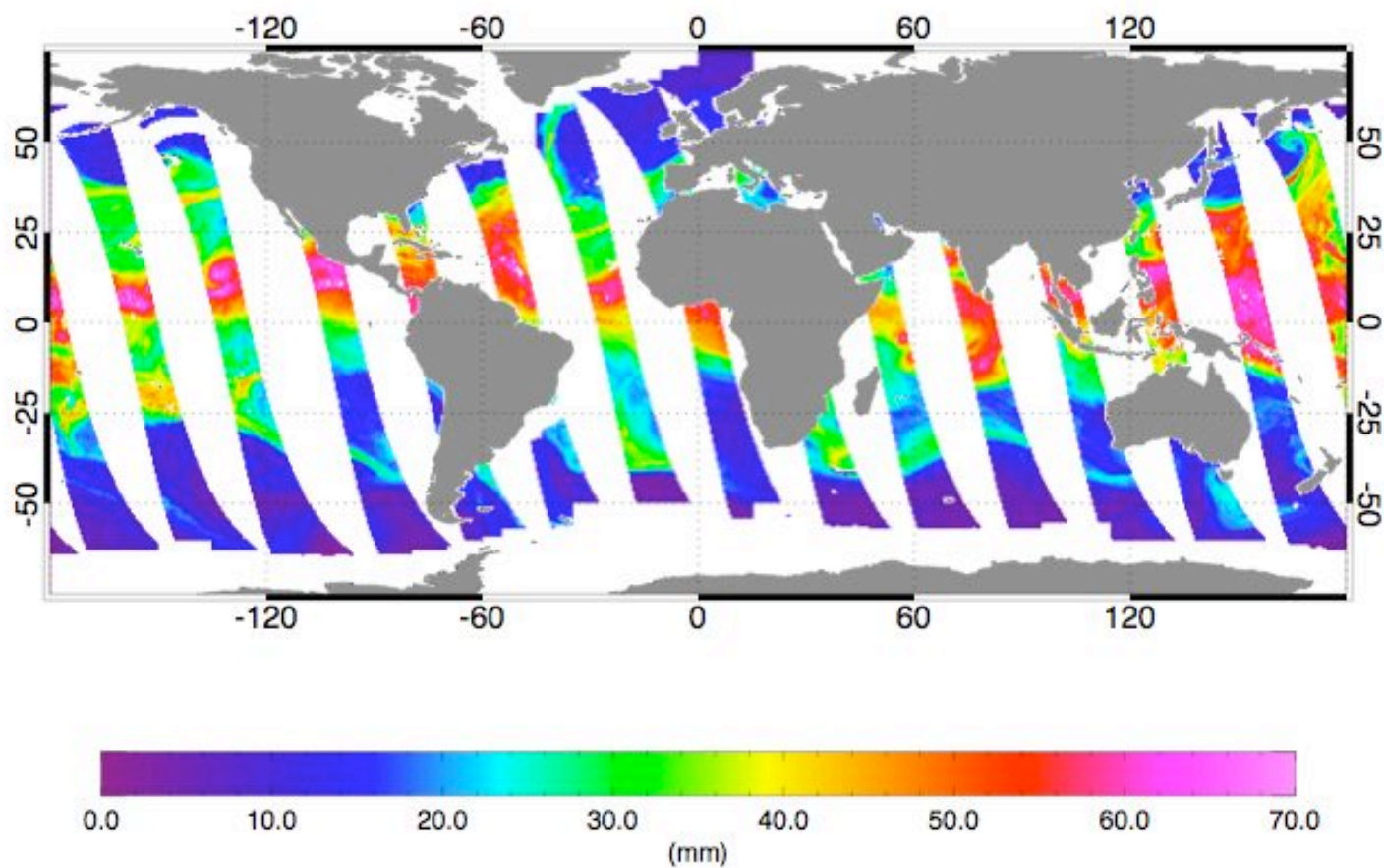**Operational Data Products Generated at FNMOC in Near Real Time**

WindSat Total Precipitable Water

WindSat Water Vapor Field
PO.DAAC 1.9.1 - No Land or RFI   Ascending   20041007
180W_180E_75S_75N

(mm)
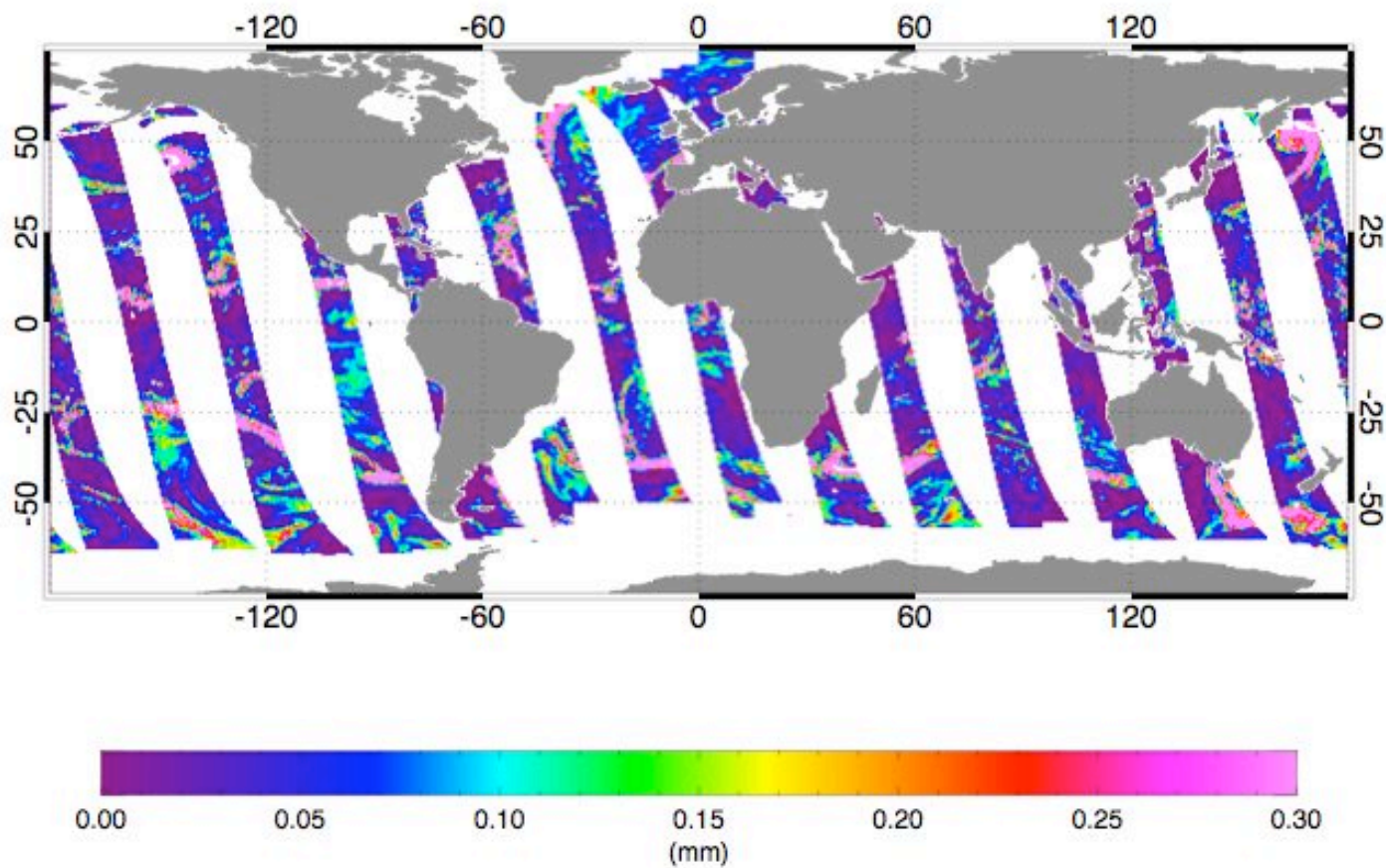
WindSat Cloud Liquid Water

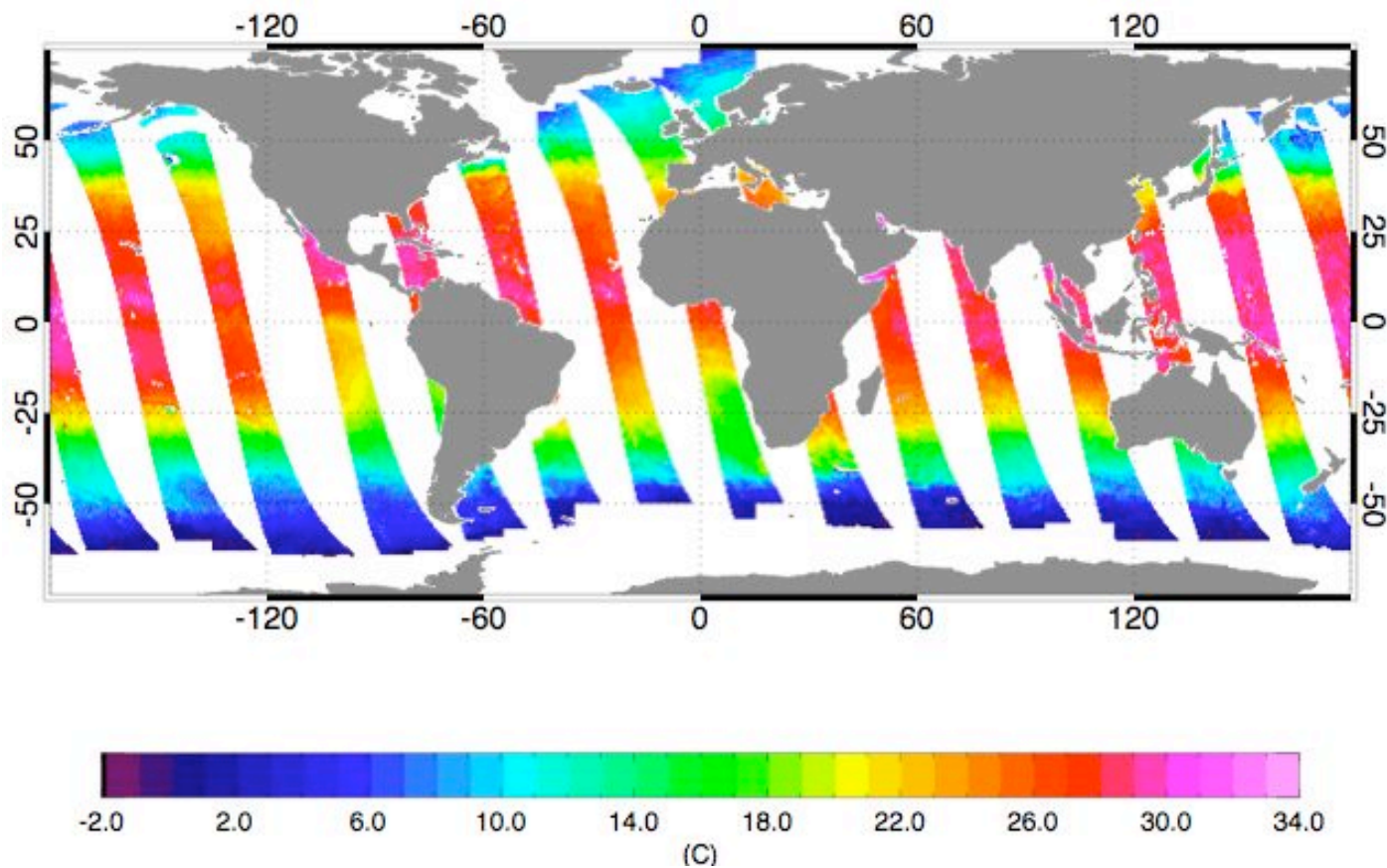PO.DAAC 1.9.1 - No Land or RFI   Ascending   20041007
180W_180E_75S_75N

WindSat SST

WindSat SST Field
PO.DAAC 1.9.1 - No Land or RFI   Ascending   20041007
180W_180E_75S_75N
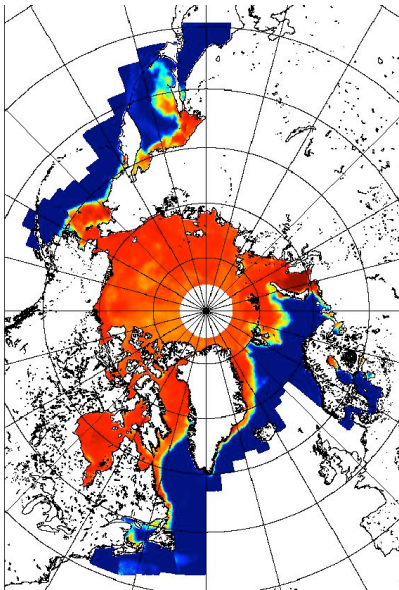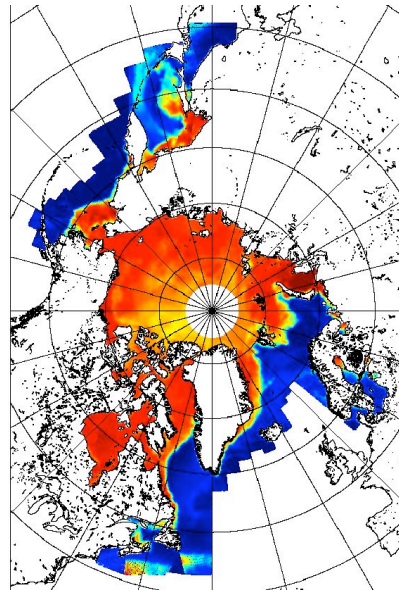
WindSat & Sea Ice

- **WindSat Channels Sensitive to Sea Ice Properties**

- **Sea Ice Concentration Based on SSM/I NASA Team Algorithm**

  - **Modified for WindSat Channels and Geometry**
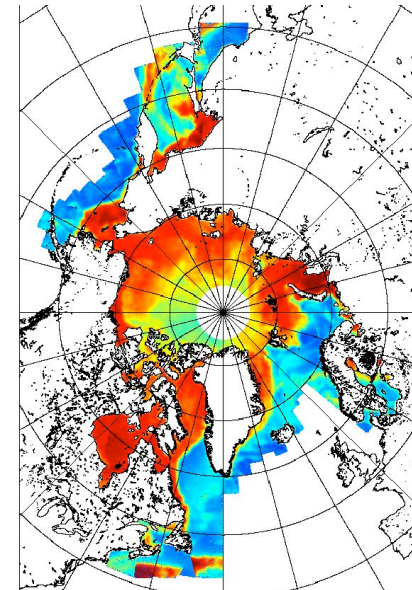
  - **Modified Weather Filter**

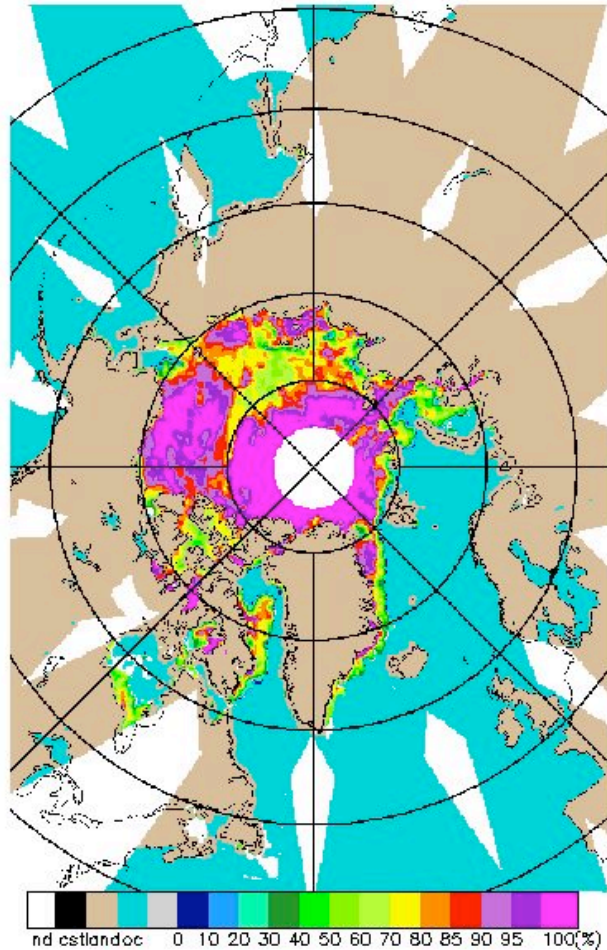| 10.7 H	10.7 H	37.0 H

3 day composite 2004 03 15-17

WindSat Level-3 Sea Ice Products

Northern Hemisphere WINDSAT
24 Hour Averaged Composite
From 12z 06/27/2006 To 12z 6/28/2006

nd cstlandoc   0 10 20 30 40 50 60 70 80 85 90 95 100(%)

NIC – Polar Science Team / NRL – WindSat Team

Southern Hemisphere WINDSAT
24 Hour Averaged Composite
From 12z 06/27/2006 To 12z 6/28/2006

nd cstlandoc   0 10 20 30 40 50 60 70 80 85 90 95 100(%)
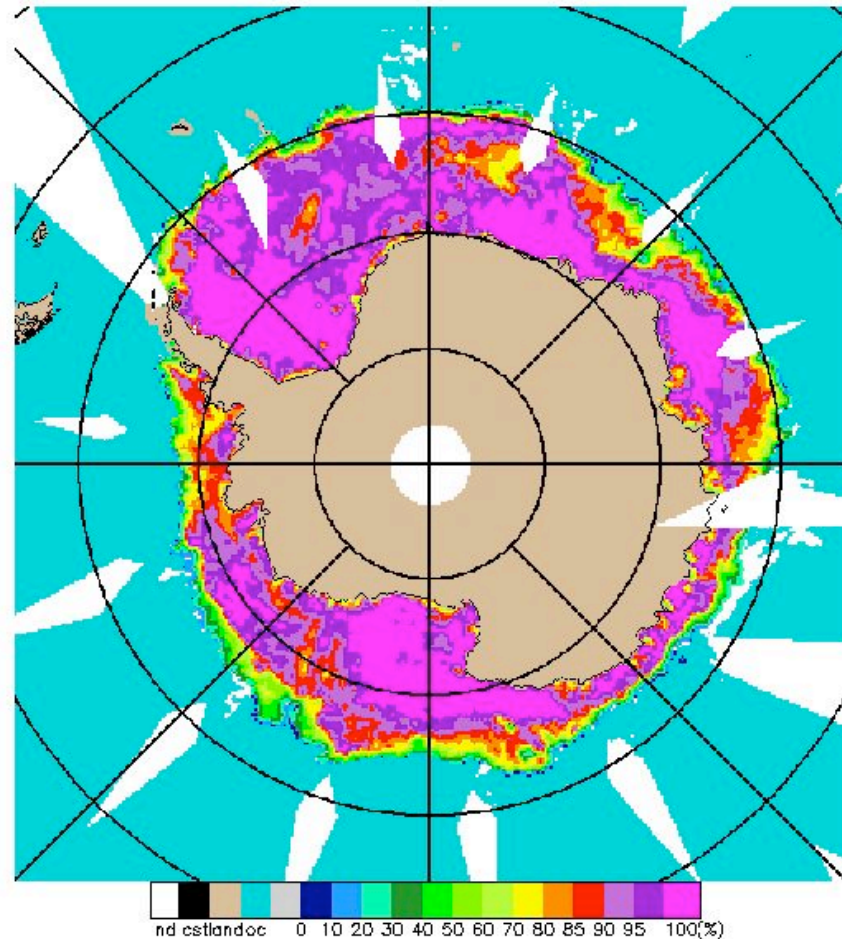
NIC – Polar Science Team / NRL – WindSat Team

WindSat Global Soil Moisture and Vegetation Water Content

- *NRL WindSat physically-based retrieval performs simultaneous soil moisture and vegetation retrievals*

- *No direct vegetation calibration/validation.*

- *Global soil moisture patterns are consistent with dry/wet patterns of climate regimes.*

- *Good agreement between WindSat retrieved Vegetation Water Content and AVHRR derived Green Vegetation Fraction*

1 – 12 Sep. 2003
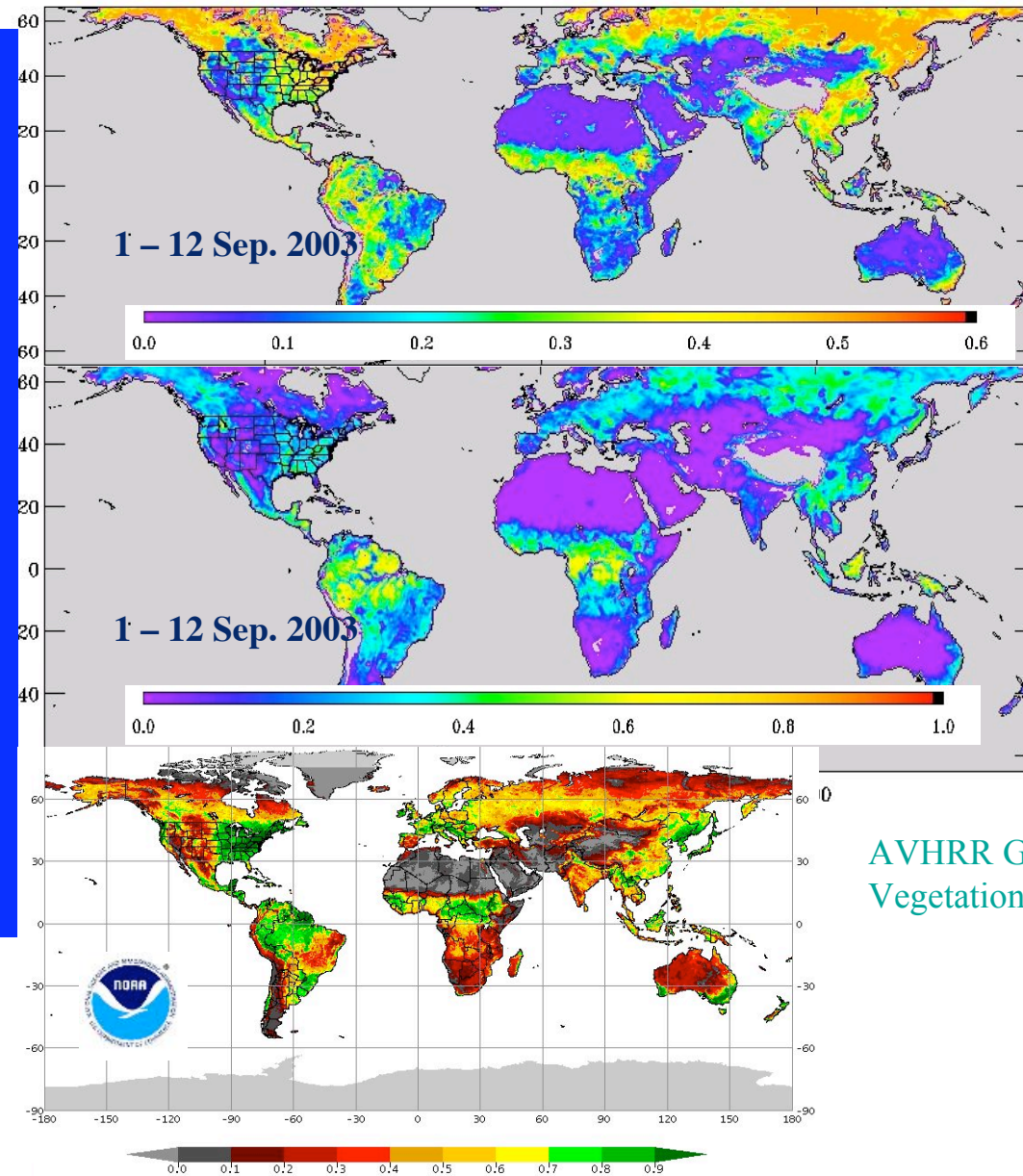
Volumetric Soil Moisture (Fraction)

1 – 12 Sep. 2003

Vegetation Water Content (kg/m^2)

AVHRR Green Vegetation Fraction
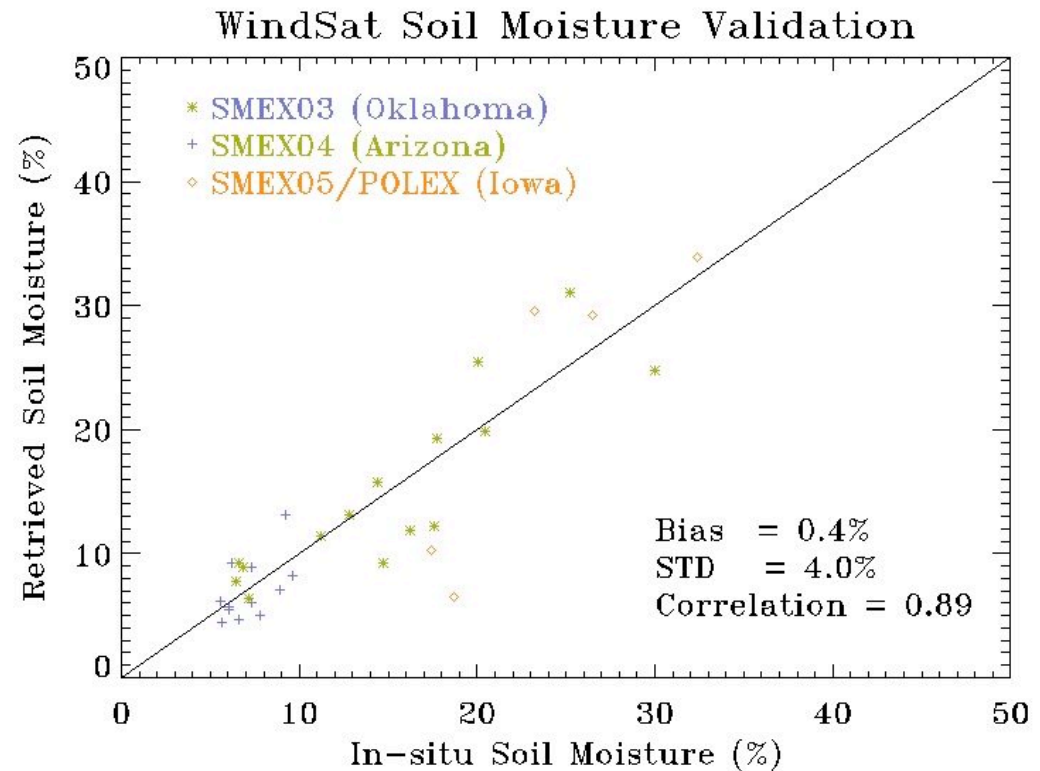
WindSat Soil Moisture Validation
SMEX 2003 - 2005

Preliminary US Validation:
WindSat soil moisture algorithm is validated in various conditions using SMEX data

WindSat Retrieval Uncertainty:
4% with 0.4% bias volumetric soil moisture at 50 km Horizontal Cell Size (HCS) for low to moderate vegetated land.
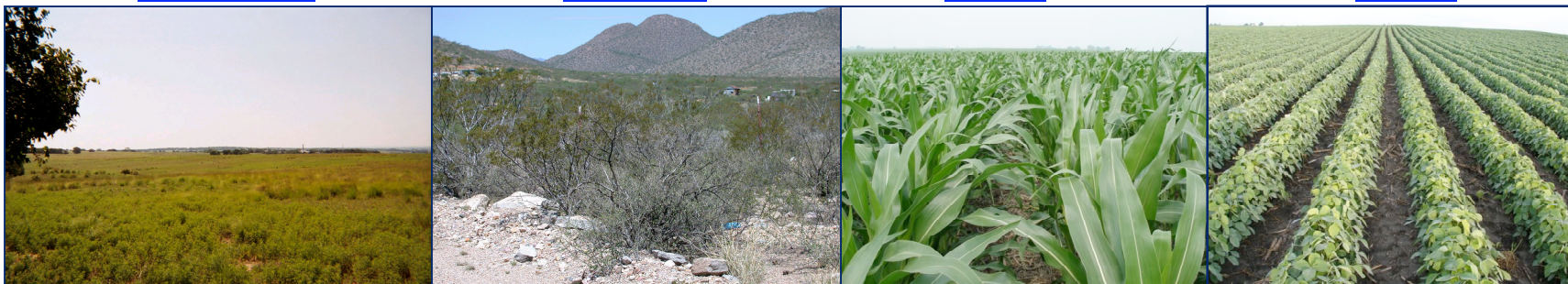

WindSat Soil Moisture Validation

* SMEX03 (Oklahoma)
+ SMEX04 (Arizona)
◇ SMEX05/POLEX (Iowa)

Bias = 0.4%
STD = 4.0%
Correlation = 0.89

Oklahoma   **Arizona**   **Iowa**   **Iowa**
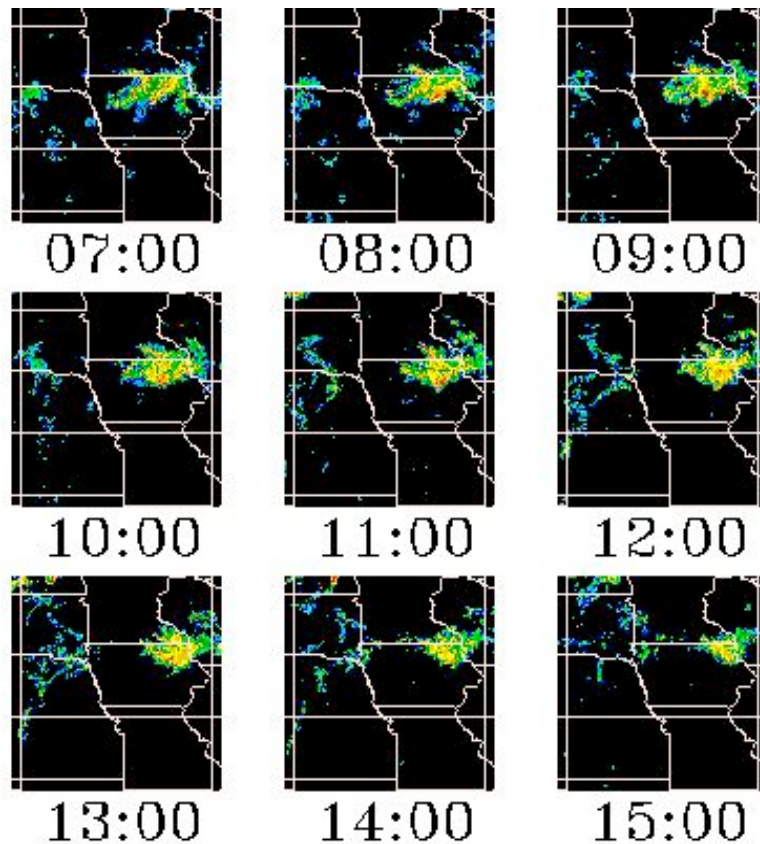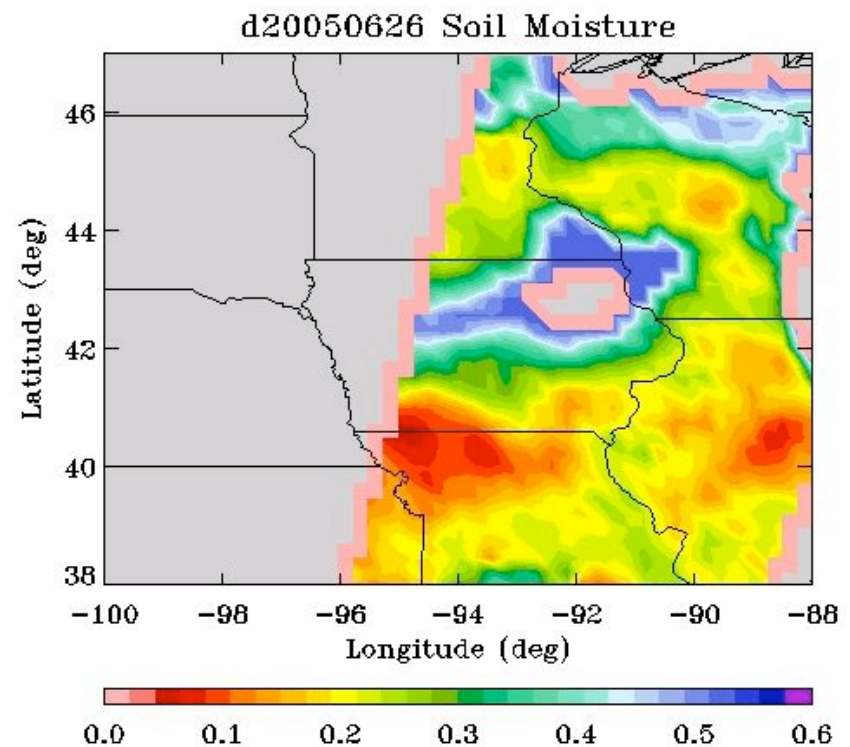
Soil Moisture Example - SMEX05

NEXRAD

Volumetric Soil Moisture

WindSat Pass @ 1226 UTC

WindSat Operational Data Utilization

- **WindSat Data Processed in Near Real Time (NRT) at Fleet Numerical Meteorological and Oceanographic Center (FNMOC)**
  - **Data Provided to Users on Shared Processing Network [NESDIS, NAVO, NRL-Monterey (NRL-MRY)]**
- **NESDIS Office of Research and Applications (STAR) Introducing Weather Service Operational Users to WindSat**
- **WindSat Products Used for Tropical Cyclone Monitoring/Forecasting**
  - **NRL-MRY, FNMOC, Joint Typhoon Warning Center, National Hurricane Center**
- **Data Assimilation into Numerical Weather Prediction (NWP) Underway**
  - **Joint Center for Satellite Data Assimilation**
  - **NOAA Atlantic Oceanographic and Meteorological Laboratory**
  - **NRL/FNMOC**
  - **United Kingdom Met Office**
- **Providing Sea Ice Data to National Ice Center**

Near Real Time Data Availability

- **WindSat Data is Processed in NRT at Fleet Numerical Meteorological and Oceanographic Center (FNMOC)**
  - Data is pushed to NESDIS (EDRs and SDRs) and NAVO (EDRs)
  - Data also goes to NRL-MRY for Tropical Cyclone Web Page and Data Assimilation Projects

- **WindSat NRT Data is Available via the Shared Processing Network**
  - Contact:

    Peter Gaiser at NRL (peter.gaiser@nrl.navy.mil) or

    Gene Legg at NESDIS (gene.legg@noaa.gov)

- **Documentation is Available**
  - Data Descriptions, User Guide, Release Notes, File Formats, Reader Programs

WindSat Team Is Happy to Support Users
peter.gaiser@nrl.navy.mil
http://www.nrl.navy.mil/WindSat

Summary

- **WindSat Successfully Demonstrated Measurement of Ocean Surface Wind Vector with Polarimetric Radiometry**

- **Providing Key Risk Reduction for Future NPOESS Microwave Imager**

- **WindSat Team Working with Science and Operational Communities to Capitalize on the Unique WindSat Data Set to Fully Exploit Its Potential**

  - **Ocean Products**

  - **Data Assimilation**

  - **Land and Vegetation**

  - **Snow and Ice**

  - **Breaking Waves and Sea Salt Aerosols**